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The Challenge of Managing a Spacelab Program

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THE CHALLENGE OF MANAGING A SPACELAB PROGRAM

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ABSTRACT

The Spacelab concept of providing standard, reusable accommodations for Orbiter-attached payloads has the promise of yielding highly rewarding research. Although NASA experience with aircraft, sounding rockets, Skylab and free flyers can be applied to Spacelab payload management, new and innovative management approaches must be tailored to meet unique Spacelab and STS requirements.

This paper will discuss from a Spacelab Payload Manager's perspective the major management challenges which must be successfully overcome if payload programs are to not only exist but thrive. Specific management strategies for meeting these challenges will also be discussed.

INTRODUCTION

A little more than a year and a half ago, I enthusiastically accepted an offer to lead Goddard Space Flight Center's Shuttle Spacelab Payloads Project (SSPP). The Project was charged with establishing a capability to effectively utilize the Spacelab element of the Space Transportation System (STS). Although there were problems to overcome, the prospects of influencing the shape of the new STS were exciting and challenging. But, because of the problems, there was little doubt: For the STS to be successful, some innovative changes would be necessary.

Why is change necessary? First, space research capabilities, as represented by the Shuttle/STS, are expanding and becoming increasingly sophisticated in their use. Forty to sixty Shuttle launches per year, by itself, will require a different approach to STS operations. Second, NASA has a reputation for excellence in accomplishing its objectives. This tradition is too strong to permit failure; therefore, we will--no we must adapt to this new environment and its problems. Third, NASA as an organization has more than 20 years experience in developing and integrating space flight systems. At the Goddard Space Flight Center, this means that we have repeated the basic process more than 140 times on spacecraft and 1,500 times on individual instruments. Similar, but somewhat different, experience could be recounted by other NASA Centers. It is from this foundation that we must build. This assessment would be incomplete if it failed to mention the pervasive twin economic pressures of scarce funding and manpower whose effects often dictate compromise.

This paper will specifically address the Project's role in developing payloads which take advantage of STS capabilities and in establishing an efficient process for executing Spacelab missions. The major challenge facing the Project is how best to make use of the unique STS capability to do cost effective scientific and applications research. A key element in meeting this challenge is insuring that the uses for the Spacelab are appropriate to its unique capabilities.

SPACELAB UTILIZATION

WHAT IS SPACELAB?

Perhaps it is best to begin by defining Spacelab. The Spacelab, when combined with the Orbiter, is a standard, reusable spacecraft for accommodating attached payloads requiring 7-30 day orbital stay times. When man is added to this complement, Spacelab represents a unique and extremely versatile platform for spaceborne research. Some of the more valuable uses of Spacelab are:

A. Free-flyer substitute--for technical or economic reasons, a free-flying spacecraft may not be compatible with a user's requirements. In some cases, until the technology advances to the point where a free-flyer becomes feasible and economical, Spacelab may indeed be the only alternative for conducting spaceborne research. Examples are large payloads for which a unique spacecraft would be clearly uneconomical, or instruments whose sensor technology does not readily permit a free-flyer solution such as the large cryogenically cooled Shuttle Infrared Telescope Facility (SIRTF), or an experiment which requires high power consumption such as material processing furnaces and active laser sensors.

B. Human Interaction--although, in some cases, robots and other computer controlled machines have proven to be valuable, they can also be extremely expensive or poor substitutes when on-the-spot judgments are necessary. The human being as a subject for life sciences experiments should also be included in this category. Discriminating use of human interactive capability can significantly enhance the results of certain investigations.

C. Payload Reflights--in this category, planned payload changes between flights are required to accomplish mission or investigation objectives. This capability is often incompatible or uneconomical with free-flying spacecraft. Examples are specialized multiuser facilities such as the Solar Optical Telescope and the SIRTF which, through their allowance for changes in focal plane instrumentation, permit science missions to evolve in response to the state of current knowledge. Furthermore, the basic facility itself can be improved and refined in an evolutionary manner. Another example is a calibration program interspersed between flights to assure the integrity of very precise measurements. Also, the payload return capability inherent in this category should not be overlooked. It provides a very valuable Spacelab service, the use and return of photographic film.

D. Test Bed—this capability provides a true-to-life space laboratory environment with which to resolve technological and operational uncertainties or questions. Knowledge obtained through this process may be used to design a permanent Spacelab or free-flyer component, instrument or facility. Sometimes this method may be used to successfully demonstrate a technique before committing to an operational system.

Thus far, atmospheric and space plasmas, physics, life sciences, and materials processing are research disciplines which appear to have made the best use of Spacelab's unique capabilities. In general, the mature Spacelab ground and flight system should provide a means for satisfying requirements for a rapid response to changing space research problems. For some uses, a significant question persists: Is the present constraint of 7 to 30 days for a Spacelab mission worth the cost? The discussion immediately following will describe an approach for determining the most appropriate uses for Spacelab.

CRITICAL CHOICES

Although you now have an idea of how Spacelab could be used, successfully determining the most appropriate uses for Spacelab will depend on: (1) The pursuit of program goals and objectives uniquely, or at least, optimally suited to the Spacelab capabilities such as those described previously, (2) The identification of high priority Spacelab investigations, payloads and missions, and (3) A critical assessment and feedback of experiences from early Spacelab missions. All of the above must be decided in a world of ever increasing space capabilities and operational alternatives. What follows is a simplified examination of how these critical choices might be made.

PROGRAM GOALS AND OBJECTIVES

Research program goals and objectives for Spacelab can only be determined by relating research or science interests, in terms of performance requirements, to the capabilities offered by the Spacelab. But, because of the growing number of alternative space research platforms (aircraft, balloons, sounding rockets, Spacelab, Explorers, Multi-mission spacecraft, unique observatory spacecraft, and possible in the near future, large space platforms), deciding which interests to pursue with Spacelab cannot be made in isolation. The attributes of these alternative approaches and how well they could satisfy the desired performance requirements must be assessed. One can imagine a decision tree type of analysis where, for each science interest, explicit performance requirements can be obtained, then assessed against the capabilities of Spacelab and the other alternatives. Ultimately, the development of explicit criteria for optimal uses of Spacelab, as well as other platforms, would result. A major benefit could be a more efficient process for use by the research community and NASA for determining the allocation of scarce resources among competing alternatives.

MISSION DEVELOPMENT

Once Spacelab program goals and objectives have been established, the next step is to solicit investigations (experiments), payloads, and missions which contribute to the major program thrusts. Ideally, only those proposals which exploit Spacelab capabilities, contribute to the solution of major research problems or new discoveries, and are accepted as a worthwhile undertaking by researchers and management alike, should be selected for implementation. It would also be most helpful if there is a compelling reason to complete the mission sooner rather than later. If this part of the process is carried out properly, what will have been accomplished is the identification of compelling and urgent reasons for Spacelab missions. Most planned human endeavors of any consequence, including space missions, possess these characteristics.

REFINING THE PROCESS

It should not be forgotten that Spacelab, being a fairly new concept, is itself an experiment. Therefore, many of the assumptions that will have to be made regarding its operation will naturally involve varying degrees of uncertainty. It follows then that we must be especially vigilant in verifying these assumptions under flight conditions. Such vigilance will only serve to refine the process of assuring the most appropriate and effective future uses of Spacelab.

SPACELAB PAYLOAD MANAGEMENT CONSIDERATIONS

THE CHALLENGE

One of the greatest challenges facing NASA is the challenge of bringing into reality the expanded technical capabilities, cost and operational advantages that have long been claimed for the STS concept. Some of these capabilities such as added mass and volume and payload retrieval and return have already been designed into the STS and will be relatively easy to achieve. A somewhat more difficult challenge is the goal of simple, low-cost, routine and more frequent access to space. This is basically the challenge accepted by our Project: Establishing a simple, efficient system for Spacelab payload development, integration and operations.

AN ASSESSMENT

Before establishing such a system, the Project gave considerable attention to what the operational STS era would be like. The answer: (1) Increased interfaces as a result of the many separate elements making up a single mission (instruments, flight support equipment, Spacelab, and orbiter); (2) Large volume operations--volume because of its multidimensional aspect such as high launch rate and payload complexity; (3) Standard spacecraft bus and payload interfaces with numerous expanded capabilities; (4) Considerable payload integration experience resides in both government and industry (no new technology); (5) Technological challenges are in the development of new instrumentation; (6) Ground and flight systems must be able to handle the future missions whose engineering and operational requirements are unknown and are continuously evolving. It was from assessments such as these that the Project's implementation strategies and approaches have evolved, and are continuously evolving.

IMPLEMENTATION STRATEGIES

Now that something is known about the situation with which we are dealing, the important question remaining is how to do the job efficiently. At Goddard, we have built our strategies around certain unifying principles which, in themselves, will foster management efficiency and optimal use of Spacelab systems. Furthermore, it is our belief that these principles are well-suited to the operational environment of the future discussed in the preceding text. A brief description of these principles follows:

A. Production Line Similarities--Spacelab's potentially large volume operations, together with the idea of a standard spacecraft with standard interfaces, is somewhat analogous to an assembly or production line. For example, both payload development and integration activities contain a finite number of functions which are performed over and over again for each instrument and for each mission. This analogy applies equally well to "soft" systems such as project management functions, as well as, "hard" systems such as the hands-on hardware integration functions. For the production principle to pay-off, almost as much attention will have to be paid to the process as is presently paid to the product. The efficiencies inherent in these production-like Spacelab processes should be exploited for their obvious cost savings.

B. Autonomy--Because of the large number of interfaces and organizations (Headquarters Office of Space Science and Office of Space Transportation System, Johnson Space Center, Marshall Space Flight Center, Kennedy Space Center, Goddard Space Flight Center Principal Investigator Institutions, and contractors) required to execute a Spacelab mission, it is vitally important that interdependence be minimized. In other words, the maximum autonomy that is reasonably possible must be promoted for not only instrument, payload and STS mission elements; but also Headquarters, Centers and Project organizations. Unless organizational entities are able to fulfill their obligations according to comprehensive standardized interface agreements, with only a reasonable amount of special interaction, much of the promise of the STS, such as frequent, uncomplicated access to space may never be realized. The system could easily fail to operate as a result of its internally generated encumbrances.

At Goddard, some of our more promising strategies for achieving Spacelab objectives are based on this principle of maximizing autonomy. The development of instruments without mission assignment frees the developer from the pressure of mission schedules. The use of performance oriented end-item contracts delegates more responsibility and, hence, more independence to contractors to manage their internal resources. The development of policy guidelines and procedures early in a program allows operating decisions to be made more rapidly and at a lower level. Also, the project plans to give special attention to engineering and operational interfaces to minimize their impact on the integration process. And, of course, the success of our principle regarding production-line processes is dependent on the principle of autonomy.

Each of the above strategies permits more authority and responsibility to be delegated; as a result, greater independence from other elements in the system is achieved.

C. Flexibility--In the Spacelab program, we are establishing ground processing and flight systems which are able to support a large number of users on each individual flight, and whose specific requirements for each particular mission are presently unknown. To further complicate matters, Spacelab will handle a wide-ranging and varied assortment of missions. Therefore, we have been proponents of ground and flight systems that have the flexibility of satisfying a full range of future, as yet undetermined, but someday, very specific mission requirements.

Such a system, if it is to remain relatively low in cost and free of complication, must be managed and controlled.

Criteria must be established for determining, in advance, how the more critical and costly resources such as on-board crew use, Spacelab computer capacity, and Payload Operations Control Center (POCC) support will be allocated among users. These criteria must be applied in an even-handed fashion, and, together with information and other STS services, provided so as to promote maximum Spacelab utility.

D. Knowledge—The creation of a Spacelab mission involves many highly specialized talents and skills residing in universities, government and industry. If the system for planning and executing Spacelab missions is to be efficient and effective, then the utilization of these valuable resources will have to be optimized. Spacelab management should avoid replicating effort which has already been expended at earlier stages in the process. We should also assure the most effective application of the backgrounds and experiences of participating organizations.

At Goddard, we have attempted to apply this principle in several ways. To minimize the costly and sometime ineffective formal transfer of information from the Principal Investigator (PI) to the government and contractor, the knowledge and capabilities possessed by the PI and his team will be used when and where it is sensible to do so. Likewise, assigning payload integration responsibility to industry, which has considerable experience in this area, (considerably more than the government when the production aspect is taken into account) seems appropriate. Moreover, why do any more than specify requirements in a Request for Proposal (RFP), since the bidder should know how to most efficently and effectively apply his resources? Government manpower can be reserved for other critical functions such as the development and management of activities having greater technological uncertainty.

E. Risk Management--Bringing the STS, Spacelab and their capabilities into reality will require technical and management innovations. Innovation, which usually implies rewards, is also another way of implying risks. However, when the potential rewards are sufficiently large, tradition must make way for new ideas and approaches. The Project, in consideration of the repeating nature of the Spacelab payload processes, plans to moderate risk in this area by utilizing existing techniques when they are cost effective, by experimenting with new techniques where innovation seems most likely to pay off, and once proven, by widely disseminating these new techniques to users.

Naturally, risks will also result from the basic immaturity of the Spacelab and the STS. At Goddard, in recognition of the Spacelab's immaturity, we hope to lower this element of risk by keeping our early missions simple and uncomplicated, evolving to the more complex after gaining experience and refining our processes. Also, for the more complex undertakings, we consistently ask the question: Is an evolutionary strategy in order?

Of course, there are other risks, including those associated with the overall management approach used by NASA. However, after more than 20 years of far reaching space activities, NASA and industry should have the experience to intelligently manage risk.

CONCLUSION

Much effort is needed before the STS promise, as envisioned by its creators, becomes reality. First, we must continue to take bold steps in formulating imaginative and compelling Spacelab uses which effectively exploit the potential capabilities of the system. Second, we must break with those traditions whose time has passed, and which would therefore preclude Spacelab integration from becoming a simple, smoothly flowing, efficient process. Third, we must make optimal use of the capabilities which exist in NASA, the research communities, and private industry.

Finally, probably more important than anything, we must have both vision and commitment. A vision of what is ideally desirable and really necessary for successful Spacelab/STS operations, and a commitment to achieving that part of the vision which is practical and beneficial to our national space objectives.